The comb of the capon fails to reach the full development of that characteristic of the Brown Leghorn cock, while in the spayed female the comb becomes male-like in certain individuals at least. The spurs develop on the capon as well as on the cock—a result that shows that this secondary sexual character at least is little if at all affected by the removal of the testes. In the Brown Leghorn hen and more commonly in other breeds, spurs may occur on the female occasionally, and even be developed as completely as in the male, but they developed *in all* the successfully spayed females. In the light of the occasional occurrence of spur in the female, the results after spaying can not be definitely ascribed to the absence of the ovary, although this is the more probable conclusion.

In castrated drakes and in spayed ducks the voice remains normal "except that some castrated females occasionally give voice to a sound similar to the drake's." In fowls, on the other hand, both sexes after gonadectomy "are disinclined to give voice," although capons may give all the sounds characteristic of clarion (but rarely do so). The spayed females were not observed to crow.

At the time when Goodale's paper was written the effect of castration on hen-feathered males (that are characteristic of certain races, notably Sebrights, Hamburgs and Campines) was not known. Since then the reviewer has shown that not only the F_1 (dominant) and F_2 hen-feathered males assume the full plumage of the cock, but that this holds true for the pure Sebright cock also.

Goodale discusses the nature of the influence that brings about the change after removal of the ovary and concludes that the ovary secretes some substance that holds in check the development of full male characters that may be assumed to be inherited through *both* sexes. A parallel case is furnished by the experiments referred to above, in crosses of Sebrights and Black Breasted Game Bantams, that show that hen feathering is transmitted as a non-sex-linked character both by the hen and by the cock. Cock feathering develops in the hen-feathered cock after castration, as well as in the hen when old (according to a brief notice by Darwin in "Animals and Plants," Chapter XIII., Vol. 11, p. 29). The probable nature of such an internal secretion is discussed by Goodale in the following significant statement (page 49):

> The adjustment of the ovarian secretion to the characters it modifies is very close, as shown by the fact that the male characters produced in a given female are like those of the corresponding male. . . . From this we may conclude that the secretion on the whole is relatively simple and probably of uniform nature. If the secretion were composed of many substances, one to produce each effect involved, such as the change from a vermiculated feather to penciled, from a gray and white to a black and brown, the resulting complexity would be so great that one would not anticipate any such close coordination as actually results. For purposes of illustration we may assume that the ovarian secretion is simple, producing its effect by oxidation or some other simple process. The sort of result produced by oxidation, of course, depends upon the substance that is oxidized.

It need scarcely be added that this statement furnishes no grounds for the identification of the enzyme produced in the testes with the factor or factors that represent it in the sex chromosome, viz., the sex-determining factors. It is possible, of course, that the sex factors are enzymes, but there is not the slightest warrant for drawing the conclusion that they are (as some recent writers have done) from genetic evidence of this kind, for it is also possible that there may be a long series of reactions between the chemical substance in the chromosome that we may identify if it pleases us to do so as the genetic factor, and the enzyme that develops later when the testes are formed.

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SPECIAL ARTICLES

THE BEHAVIOR OF CERTAIN GELS USEFUL IN THE INTERPRETATION OF THE ACTION OF PLANTS

The amorphous carbohydrates constitute a very important part of the colloids of the

protoplast, the remainder of which consists largely of nitrogenous material, in the form of albumen or albumen derivatives with an unknown amount of lipin. The search for material which might simulate the imbitional behavior of growing tracts in plants begun by the senior author resulted in finding that mixtures of agar with gelatine in which the last-named substance was present in the smaller proportion showed an enhanced capacity for imbibition in distilled water and a reduced swelling in weak acid and alkali as measured in very thin plates by the auxograph.[1]

It is not certain, however, that the combination of amino-acids in gelatine is duplicated in the plant and it was deemed important to test the effects of simpler amino-acid compounds and of the more complex albumens on the swelling of agar, as representing the basically important carbohydrates. Solutions of the various mixtures were poured on glass plates in layers about a centimeter thick and 3 by 5 cm. in area. Desiccation resulted in a reduction of the length and width to about half of the original. The thickness, however, was reduced to one tenth or even as much as to one thirtieth of the original, and having a thickness of .1 mm. to .3 mm. in most cases. The principal axis of deposition of material was in the vertical and the swelling in this direction would of course be correspondingly in excess of that in the plane of the sections. It is extremely unlikely that any of the colloidal masses of the cell are iso-radial as to deposition or structure and the use of thin plates seemed a feature which might increase the similarity of behavior with that of the plant. The strands, sheets or masses of material in the cell are of course mostly thinner than the plates used in the experiments, which however, would affect speed of imbibition more than total amount.

Trios of sections of sheets of the dried colloids 2 to 4 mm. by 3 to 6 mm. were placed in the bottom of stender dishes or of heavy watch glasses securely seated on iron cylinders. Triangles of glass were placed on the sections, and the vertical arms of auxographs were rested in a socket in the center of the triangles. Any change in thickness of the sections would be registered immediately. The use of six instruments gave duplicate results of the effects of water, acid and alkali, and each record was an integration or average of the swelling of three sections.

The only albumen available when this plan was put into operation was a commercial egg-albumen, and this was first tested in mixtures with large proportions of gelatine. The results of the swellings are as follows:

Water	HCl *N*/100	NaOH *N*/100
	Gelatine	
	(Average of 3 tests)	
313.8%	825.5%	558.3%
	Gelatine 100—Albumen 5	
	(Average of 5 tests)	
283.4	611.7	482.2
	Gelatine 85—Albumen 15	
	(Average of 5 tests)	
408.6	827.8	673.0
	Gelatine 75—Albumen 25	
	(Average of 3 tests)	
378.3	569.7	508.7

The albumen did not exert any important influence on the swelling of the mixture until it was present in proportions as great as 25 per cent. The action is not marked even in this high proportion. Neither this nor any other combination in which gelatine formed the greater part displayed water relations at all similar to those of the plant.

Next egg-albumen was added to agar and agar-gelatine mixtures with results as below, a further illustrative test being made of agar-gelatine:

Water	HCl *N*/100	NaOH *N*/100
	Agar 75—Gelatine 25	
	(Average of 4 tests)	
378.5%	427.3%	515.7%
	Agar 90—Albumen 10	
	(Average of 3 tests)	
1,516.6	270.0	333.3
	(Average of 6 tests)	
1,477.1	309.8	297.9
	Agar 90—Gelatine 10	
595.0	216.6	298.6

The addition of ten per cent. of albumen to agar notably reduced the capacity of agar for swelling in acid and alkali, and appeared to

[1] MacDougal, "The Imbibitional Swelling of Plants and Colloidal Mixtures," SCIENCE, N. S., Vol. XLIV., pp. 502–505, 1916.

increase the amplitude of swelling in distilled water, although the last matter is not entirely clear. The albumen reduced the swelling of a mixture containing twenty-five per cent. of gelatine slightly in acid and in alkali, but the swelling in water was not markedly greater. This preliminary test yielded results which made their extension highly desirable. Chemical analyses of the egg-albumen were not available, and as nothing was known as to the salts or other substances which might be included, it was desirable to secure material of known origin and composition. Arrangements were made with Dr. Isaac F. Harris, of Squibb and Sons Laboratory, New Brunswick, New Jersey, to prepare some albumen from beans (*Phaseolus*) and from oats (*Avena*) to be used in the mixtures. The preparations from *Phaseolus* were available in February, 1917, and the first tests were made with the "protein" extract.

Agar and gelatine were dissolved in the usual way and the temperature of the solution allowed to fall to a point below 40° C. before the protein was stirred into it. In the course of the cooling and drying cloudy masses became visible which were taken to be the globulin component of the protein. The dried sheets came down to a thickness of .3 to .4 mm. Calibrated samples were tested in trios under the auxograph in the usual manner. Two complete series of all mixtures were made and an additional measurement of the action of water and alkali were obtained. The swellings were as follows:

	Water	HCl *N*/100	NaOH *N*/100
	Gelatine 90—Protein 10 (*Phaseolus*)		
	585.7%	1,401.0%	942.8%
	486.0	1,200.0	704.3
	386.0	———	800.0
Averages:	485.9	1,300.5	817.7
	Gelatine 75—Protein 25 (*Phaseolus*)		
	696.9	818.1	621.2
	500.0	1,060.6	848.4
Averages:	598.5	939.4	734.8
	Agar 90—Protein 10 (*Phaseolus*)		
	800.0	50.0	150.0
	800.0	75.0	150.0
Averages:	800.0	62.5	150.0
	Agar 99—Protein 1 (*Phaseolus*)		
	1,080.0	300.0	220.0
	800.0	360.0	240.0
Averages:	940.0	330.0	230.0

The protein extract from the bean was thus shown to exert an influence on the swelling of agar similar to that of egg-albumen in reducing the amount of swelling in acid and alkali, and increasing it in distilled water.

The next step of importance was to ascertain the effect of some of the simpler amino-acids which might be derived from the albumens in the plant. Tyrosin and cystin were available. As an example of the method the first preparation of tyrosin was one in which one part of this substance in solution was stirred into a liquefied mass of ten parts of agar at a temperature of 32° C. This was poured on a glass slab, and as desiccation was carried out the tyrosin began to collect as a flour-like efflorescence on the surface, and apparently a large part of the substance came out in this way, so that the actual proportion of the amino-acid in the dried plate was probably not more than a fourth of the amount originally used.

The dried plate of material came down to a thickness of .15 mm. and gave the following results:

SWELLING

	Water	HCl *N*/100	NaOH *N*/100
	Agar 90—Tyrosin 10 (less by efflorescence)		
	1,600.0%	133.3%	133.3%
	1,200.0	233.3	100.0
Averages:	1,400.0	183.3	116.6

A similar preparation of agar and cystin gave the following as an average of three tests:

Water	HCl *N*/100	NaOH *N*/100
	Agar 90—Cystin 10	
2,333.3%	583.1%	328.6%

A similar mixture of agar and urea (agar 90 parts, urea 10 parts) gave the following:

Water	HCl *N*/100	NaOH *N*/100
	SWELLING	
2,173.0%	716.6%	560.2%

Urea, the amino-acids, gelatine, albumen, and the saline soluble proteins of the bean dissolved with agar and dried into thin plates show a greatly enhanced imbibition in water, an imbibition in hundredth-normal hydrochloric acid not more than a third of that in

water, while it is invariably less in alkaline than in acidified solutions. The interest in swelling which begins with a neutral desiccated section is, however, much less than that which attaches to the behavior of such material under changing conditions of alkalinity and acidity which are taken to occur in the living plant.

Dried plates of agar-protein, agar-tyrosin and agar-cystin .12 to .25 mm. in thickness and 3 by 4 or 5 mm. were placed in trios on the bottoms of stender dishes. Triangular pieces of glass were placed to cover the sections of colloid in each dish and an auxograph was arranged to give a bearing contact of the swinging arm on a socket in the center of the triangular plate. So long as the preparation remained in this condition the pen of the instrument traced a horizontal line on the sheet carried by the drum. Dried sections of the colloids have a very limited capacity for imbibition of acid and alkaline solutions, and hence it was desirable to start swelling or "growth" by an initial immersion of an hour in distilled water, which was poured in the dishes. After enlargement had begun hundredth-normal acid or alkaline solutions were used in alternation at intervals of one to three hours, as many as four changes being made in some cases before the total swelling capacity was reached. The results met all expectations based on theoretical considerations and the auxographic tracings might easily be mistaken for records of the variations of the length of a joint of *Opuntia,* for example.

Sections of plates 90 parts agar to "10" of tyrosin gave a tracing traversing 12 mm. vertically on the record paper during the first hour immersed in distilled water, remained stationary, making a horizontal line during the second hour, the water having been replaced with hundredth-normal hydrochloric acid, traversed 11 mm. of the scale in the third hour during which it was immersed in hundredth-normal sodium hydrate, then shrunk 5 mm. in an hour in acid, then enlarged 9 mm. in three and a half hours in alkali, after which it shrunk 3 mm. between 8:30 P.M. and 7 A.M. in acid. A change to alkali gave an enlargement of 6 mm. in two hours. The auxograph was set to multiply so that the actual enlargement in the periods noted was one twentieth of the distance traversed by the pen. The change from acidity to alkalinity is followed by the most marked effects when the colloid has taken up a fourth or a third of the possible total amount of water. Perhaps the most striking feature is the response of the colloid to acidification under the alternating conditions. Desiccated sections give a greater total swelling in acid than in alkali, but when a certain amount of swelling has already taken place under neutral or alkaline conditions no further increase in acid solutions takes place and actual shrinkage ensues. A change to alkalinity is always followed by increased imbibition.

The experiment in question has many features similar to those of the plant. Changes from alkalinity to acidity and the reverse must be made quickly to avoid instrumental error, consequently some acid or alkali is not removed from the dish. The plate of swelling colloid is saturated with the liquid which is being removed and neutralization, acidification or the reverse does not occur for some time. Such conditions prevail in the plant and come about even more slowly.

The disintegration of the acid of *Opuntia* beginning at daybreak does not overtake the formation of this substance until as late as 4 P.M. Whether complete neutralization or alkaline conditions ever occur in this plant is doubtful. There is ground for the assumption that it does in other plants, however.

The almost rhythmic undulations of the auxographic tracing of the elongation of a wheat leaf corroborated by measurements with the horizontal microscope suggest that growth in this organ may be accompanied by metabolic processes by which the balance of acidity and alkalinity falls now on this and then on that side, there being of course possible periods in which the growing protoplasts, or some of them, were in a neutralized state. During this time, of course, imbibition might be four to eight times as great as in either acid or alkaline conditions.

The systematic endeavor to construct a colloidal mixture which would display some of the fundamental physical properties of protoplasm of plants has resulted in finding that a mixture of substances of two of the three more important groups of constituents, carbohydrates and proteins, shows the imbibitional behavior of tissues and tracts of protoplasts of the plant. The differential action of such colloidal masses in distilled water, acid and alkaline solutions yields many striking parallels with growth. The general identity of constitution of these colloidal mixtures and of cell-masses, and the obvious similarity of their behavior, together with newly determined features of carbohydrate metabolism not described in this paper, make it possible to correlate more closely the processes of imbibition, metabolism and growth, and on the bases of their interrelation, to interpret growth enlargement and incidental variations in volume and size of organs.

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SOCIETIES AND ACADEMIES

THE AMERICAN MATHEMATICAL SOCIETY

A regular meeting of the society was held at Columbia University on Saturday, April 28. The attendance included twenty-seven members. Professor E. W. Brown presided at the morning session and Professor Edward Kasner at the afternoon session. The council announced the election of the following persons to membership in the society: Professor C. F. F. Garis, Union College; Professor F. J. Holder, University of Pittsburgh; Dr. V. H. Wells, University of Michigan; Professor W. L. Wright, Lincoln University, Pa. Six applications for membership were received.

Professor L. P. Eisenhart was reelected a member of the editorial committee of the *Transactions*. A committee consisting of Professors Focke, Cairns, Cole, Huntington, Pitcher and D. T. Wilson was appointed to have charge of the arrangements for the summer meeting of the society at Cleveland, September 4–5.

The following papers were read at this meeting:

W. B. Fite: "The relation between the zeros of a solution of a linear homogeneous differential equation and those of its derivatives."

Samuel Beatty: "The inversion of an analytic function."

Maurice Fréchet: "Relations entre les notions de limite et de distance."

O. E. Glenn: "A fundamental system of formal covariants mod 2 of the binary cubic."

Luigi Bianchi: "Concerning singular transformations B_k of surfaces applicable to quadrics."

J. E. Rowe: "The projection of a line section upon the rational plane cubic curve."

L. B. Robinson: "On partial differential equations which define certain covariants."

J. K. Whittemore: "Kinematic properties of ruled surfaces."

Olive C. Hazlett: "On Huntington's set of postulates for abstract geometry."

E. F. Simonds: "Differential invariants in the plane."

J. Douglas: "On certain two-point properties of doubly infinite families of curves on an arbitrary surface."

L. P. Eisenhart: "Conjugate planar nets with equal invariants."

Alexander Pell: "Solutions of the differential equation $dx^2 + dy^2 + dz^2 = ds^2$ and their application."

C. A. Fischer: "On bilinear and n-linear functionals."

E. B. Wilson: "Classification of real strains in hyperspace."

F. H. Safford: "Irrational transformations of the general elliptic element."

J. H. Weaver: "Some algebraic curves."

R. L. Moore: "A necessary and sufficient condition that a sequence of simple arcs of specified type should be equivalent, from the standpoint of analysis situs, to a sequence of straight segments."

Dunham Jackson: "Second note on the parametric representation of an arbitrary continuous curve."

Dunham Jackson: "Roots and singular points of semi-analytic functions."

Oswald Veblen: "Doubly oriented lines."

G. M. Green: "The intersections of a straight line and a hyperquadric."

F. W. Beal: "On a congruence of circles."

G. A. Miller: "Possible characteristic operators of a group."

R. D. Carmichael: "Examples of a remarkable class of series."

W. L. Hart: "Note on infinite systems of linear equations."

F. N. Cole,
Secretary